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C6 : A Holistic Model for Decision Making in Web Services

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Abstract

Web services are playing a pivotal role in e-business, service intelligence, service science and information systems. This article will examine how the main players make decisions for activities in web service lifecycle (WSLC) and propose a holistic model for decision making in web services. More specifically, this article first examines main players in web services. It also reviews the existing web service lifecycles and proposes a demand-driven web service lifecycle for web service requesters. It will then examine six driving factors for web services, look at their interrelationships and propose a holistic model for decision making in web services, C^6, which consists of six Cs: communication, competition, coordination, collaboration, cooperation and control, taking into account the main players in web services and web service lifecycle (WSLC). The proposed approach will facilitate research and development of web services, e-services, service intelligence, service science and service computing.

Keywords

Web services (WS), web service lifecycle (WSLC), decision making, e-commerce, information systems (IS).

INTRODUCTION

Web services are Internet-based application components published using standard interface description languages and universally available via uniform communication protocols (ICWS 2009). Web services can be also considered as the provision of services over electronic networks such as the Internet and wireless networks (Rust and Kannan 2003). Web services portray a new computing paradigm that has drawn increasing attention in information technology (IT) (Deitel, et al. 2004:13), information systems (IS), and are playing a pivotal role in the field of service computing and service intelligence (Singh and Huhns 2005). Web services are also viewed as a new business paradigm that is playing an important role in e-business, e-commerce and business intelligence (Wang et al. 2006). The key motive behind the rapid development of web services is the ability to discover services that fulfil users' demands, negotiate service contracts and have the services delivered where and when the users request them (Tang et al. 2007).

The fundamental philosophy overarching web services is their ability to meet the needs of users precisely and thereby increase market share and revenue (Rust and Kannan 2003). Web services have helped users reduce the cost of IT operations and allow them to closely focus on their own core competencies (Hoffman 2003). At the same time, for business marketers, web services have proved to be very useful for improving interorganisational relationships and generating new revenue streams (Sun and Lau 2007). Furthermore, web services can be considered a further development in terms of e-commerce and e-business, because they are service-focused business paradigms that use two-way dialogues to build customized service offerings, based on knowledge and experience about users to build strong customer relationships (Rust and Kannan 2003). However, one of the most intriguing aspects effecting web services is that they cannot avoid the similar challenges encountered in traditional services such as how to make decisions in order to make associated services successful.

The web service lifecycle is a fundamental model in regards to decision making in web services. The web service lifecycle is also the basis for engineering and managing web services. For example, many techniques, approaches and methods have been proposed to facilitate and/or support the main stages of the entire web service lifecycle (Wu and Chang 2005). Many web service lifecycles have also been proposed to improve web services with their applications. For example, Narendra and Orriens (2006) consider a web service lifecycle model consisting of web service composition, execution, midstream adaptation, and re-execution. However, the existing models for web service lifecycles have not paid sufficient attention to the main players in web services and/or the demands of the main players, taking into account their decision making processes for web services. If the main players and their demands and decision making processes are ignored in web services, then the healthy future development of web services might well be problematic, because ignorance of demand in marketing will lead to economic recession.

Driving factor analysis is important for e-commerce, information systems (Chaffey 2007) and web services (Chen 2005). Driving factors and strategic analysis should both be playing important roles for the main players involved in web services. SWOT (Strengths, weaknesses, opportunities and threats) is a well-known model for studying web service and e-commerce environment (Chaffey 2007). Paul Smith (1999) developed SOSTAC™, a generic framework for e-marketing strategic planning. However, what the main players should do in decision making in web services remain open from the viewpoint of modelling and framework of web services. Further, communication, coordination, cooperation, collaboration, competition and control, (which can be represented as C^6 for brevity) have been studied in many different fields. For example, Sun and Finnie (2004) examine communication, coordination, cooperation in e-commerce from a perspective of multiagent systems (MAS). Denning and Yaholkovsky (2008) examine coordination, cooperation, collaboration for resolving large and complex problems. Then, a question arises: how do the main players in web services make decisions for activities in web service lifecycle (WSLC) based on the above mentioned C^6?.

This article will address the above mentioned issues by examining how the main players in web services make decisions for activities in the WSLC based on the above mentioned C^6. More specifically, it first examines main players in web services. It also reviews the existing web service lifecycles and proposes a demand-driven web service lifecycle for web service requesters. It will then examine six driving factors for web services, look at their interrelationships and propose a holistic model for decision making in web services, which consists of six Cs: communication, competition, coordination, collaboration, cooperation and control, taking into account the main players in web services and web service lifecycle (WSLC). The proposed approach will facilitate the research and development of web services, e-services, service intelligence, service science and service computing.

To this end, the remainder of this article is organized as follows. It first looks at main players in web services, reviews web service lifecycles, and proposes a demand-driven web service lifecycle for web service requesters. Then it examines the six driving factors for web services, C^6, and looks at their interrelationships taking into account the main players' decision making in web services and web service lifecycle (WSLC) by proposing a holistic model for decision making in web services. Finally it ends the article with some concluding remarks and some future research directions.

PLAYERS IN WEB SERVICES

This section will look at the players involved in web services and some corresponding architectures.

There are three predominant kinds of players related to web services: web service requesters, web service brokers, and web service providers (Sun and Lau 2007; Singh and Huhns 2005), as shown in Figure 1.

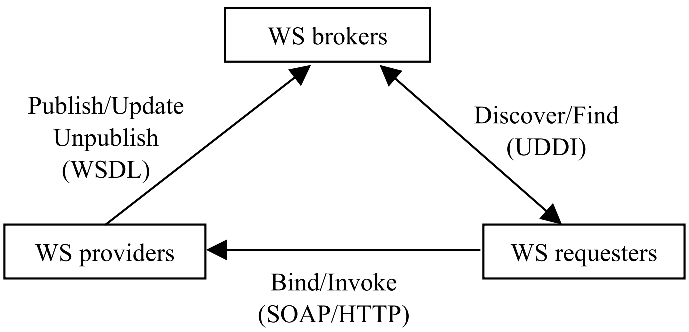

Figure 1: Players in web services

Web service requesters also denote web service users, buyers, customers, consumers, receivers, and their corresponding intelligent agents. Web service brokers encompass web service intermediaries, middle agents and their intelligent agents. Web service providers denote web service owners, sellers, senders and their intelligent agents. Web service requesters, brokers, and providers are the most integral players in web service transactions (Deitel, et al, 2004:52). Singh and Huhns include these three players in the simple service oriented architecture (SOA) for web services (Singh and Huhns 2005: 20). In the SOA architecture, web service providers create web services and advertise them to potential web service requesters by registering the web services with web service brokers, or simply offer web services (Dustar and Schreiner 2005). The web service provider also needs to describe the web service in a standard format, and publish it in a central service registry. The service registry contains additional information about the service provider, such as address and contact of the providing company, and technical details about the service. Web service providers may integrate or compose existing services (Limthanmaphon and Zhang 2003) using intelligent techniques. They may also register descriptions of services they offer, monitor and manage service execution (Dustar and Schreiner, 2005). Web service requesters retrieve the information from the registry and use the service description obtained to bind to and invoke the web service. Web service brokers maintain a registry of published web services and might introduce web service providers to web service requesters. They use universal description discovery integration (UDDI) to find the requested web services, because UDDI specifies a registry or "yellow pages" of services (Singh and Huhns 2005: 20). They also provide a searchable repository of service descriptions where service providers publish their services, service requesters find services and obtain binding information for these services.

This architecture is simple because it only includes three kinds of players (as above-mentioned) and three basic operations: publish, find and bind. In fact, some behaviours of web service agents are also fundamentally important for decision making to make web services successful. These fundamental behaviours at least include communication, interaction, collaboration, cooperation, coordination, negotiation, control, trust and deception (Singh and Huhns 2005; Sun and Finnie 2004).

Papazoglou (2003) proposes an extended service-oriented architecture. The players involved in this architecture are more than that in the simple SOA, because it includes service provider, service aggregator, service client, market maker, and service operator.

A service aggregator is a service provider that consolidates services provided by other service providers into a distinct value-added service (Papazoglou 2003). Service aggregators develop specifications and/or codes that permit the composite service to perform functions such as coordination, monitoring quality of service (QoS) and composition. In our view, a service aggregator should be differentiated from a service provider. We can use *web service recommender* to replace service aggregator, because recommendation is one of the most important activities in web services.

The main task of web market makers is to establish an efficient service-oriented market in order to facilitate the business activities among service providers to service brokers and service requesters. In the traditional market, the service broker is working in the market, while the market maker makes the market operating.

The web service operator is responsible for performing operation management functions such as operation, assurance and support (Papazoglou 2003).

From the viewpoint of multiagent systems (MAS) (Wooldridge 2002; Henderson-Sellers and Giorgini 2005), there are still other players involved in web services, such as web service advisors, web service managers, web service composers, web service recommenders, web service consultants, and so on. Further, an activity of web services usually is implemented by a few intelligent agents within a multiagent web service system (Sun and Finnie 2004). Therefore, more and more intelligent players or agents will be involved in web services with the development of automating activities of web services.

WEB SERVICE LIFECYCLE: A WEB SERVICE REQUESTER'S PERSPECTIVE

There have been many attempts to address the web service lifecycle (WSLC) in the web service community. For example, Sheth (2003) proposes a semantic web process lifecycle that consists of web description, discovery, composition and execution or orchestration. Zhang and Jeckle (2003) propose a WSLC that consists of web service (WS) modelling, development, publishing, discovery, composition, collaboration, monitoring and analytical control from a perspective of developers. Kwon (2003) proposes a WSLC consisting of four fundamental steps: WS identification, creation, use and maintenance. Narendra and Orriens (2006) consider the WSLC consisting of WS composition, execution, midstream adaptation, and re-execution. Tsalgatidou and Pilioura (2002) propose a WSLC consisting of two different layers: a basic layer and a value-added layer. The former contains WS creation, description, publishing, discovery, invocation and unpublishing. The latter contains the value-added activities of WS composition, security, brokering, reliability, billing, monitoring, transaction handling and contracting. They acknowledge that some of these activities take place at the WS requester's site, whereas others take place at the WS broker's or provider's site. However, they have not classified the proposed activities based on the WS requester, provider, and broker in detail.

Demand is an important factor for market and economy development (Jackson and McIver 2004). The demand of WS requesters or customers is the significant force for promoting the research and development of web services. In what follows, we will examine a WSLC from a WS requester's demand perspective, as shown in Figure 2.

As a WS requester, he (for brevity, we use he to represent she or he) usually searches, matches web services to meet his demands. For example, if he pays the car registration fee to VicRoad, Australia, he uses Google to search and match "VicRoad" and its web services for car registration. After he discovers a web service that meets his demands, he can pay his registration fee online. Based on this consideration, we can see that WS search, matching and discovery (Ladner 2008; Tang 2007) are the common demands of ordinary customers for web services. However, if the service requester cannot discover a satisfactory web service by himself, he has to ask an intermediary or agent for help with providing consultation, mediation and recommendation of WS to him. If the agent recommends some web services to the requester after consultation and mediation, the requester accepts one of the recommended WS after evaluation, the WS consultation, mediation (Ladner 2008) and recommendation are completed. Otherwise, the requester asks the agent to compose the web services to meet his demands. In this case, the agent will negotiate with the requester over the price for composing web services, because he needs WS adaptation. After a successful negotiation, the agent recommends the composite WS to the requester. If the requester accepts the recommended composite WS, then WS composition, adaptation, mediation and recommendation are successful. In practice, the requester also demands personalization, contracting and billing for commercial WS. Therefore, we can illustrate a demand-driven WSLC for WS requesters using Figure 2. This WSLC consists of many activities of web services such as WS search, matching, discovery, adaptation, use/reuse, consultation, composition, recommendation, negotiation, contracting and billing. All of these have drawn some attention in web services (Singh and Huhns 2005). All these activities require WS requester to make decision in order to obtain high quality of web services. In what follows, we only review WS discovery, composition and recommendation in some detail.

WS discovery is a process of finding the most appropriate web service for a WS requester (Singh and Huhns 2005). It identifies a new web service and detects an update to a previously discovered web service (Ladner 2008). There have been a variety of techniques developed for WS discovery. For example, OWL-S (of W3C) provides classes that describe what the service does, how to ask for the service, what happens when the service is carried out, and how the service can be accessed (Ladner 2008).

WS composition primarily concerns requests of WS users that cannot be satisfied by any available web services (Narendra and Orriens 2006). WS composition also refers to the process of creating personalized services from existing services by a process of dynamic discovery, integration and execution of those services in order to satisfy user requirements (Limthanmaphon and Zhang 2003). WS composition is an important topic for service computing (Wang et al 2004), because composing web services to meet the requirement of the WS requester is one of the most important decision making issues for WS providers and brokers.

WS recommendation aims to help WS requesters with selecting web services more suitable to their needs (Lorenzi and Ricci 2005). WS recommendation can be improved through optimization, analysis, forecasting, reasoning and simulation (Kwon 2003). Recommender systems have been studied and developed in e-commerce, e-business and multiagent systems (Lorenzi and Ricci 2005; Sun and Finnie 2005). Sun and Lau (2007) examine case based web service recommendation. However, how to integrate WS discovery, composition, and recommendation in a unified way is still a big issue for web services. This article will not go into this issue more detail.

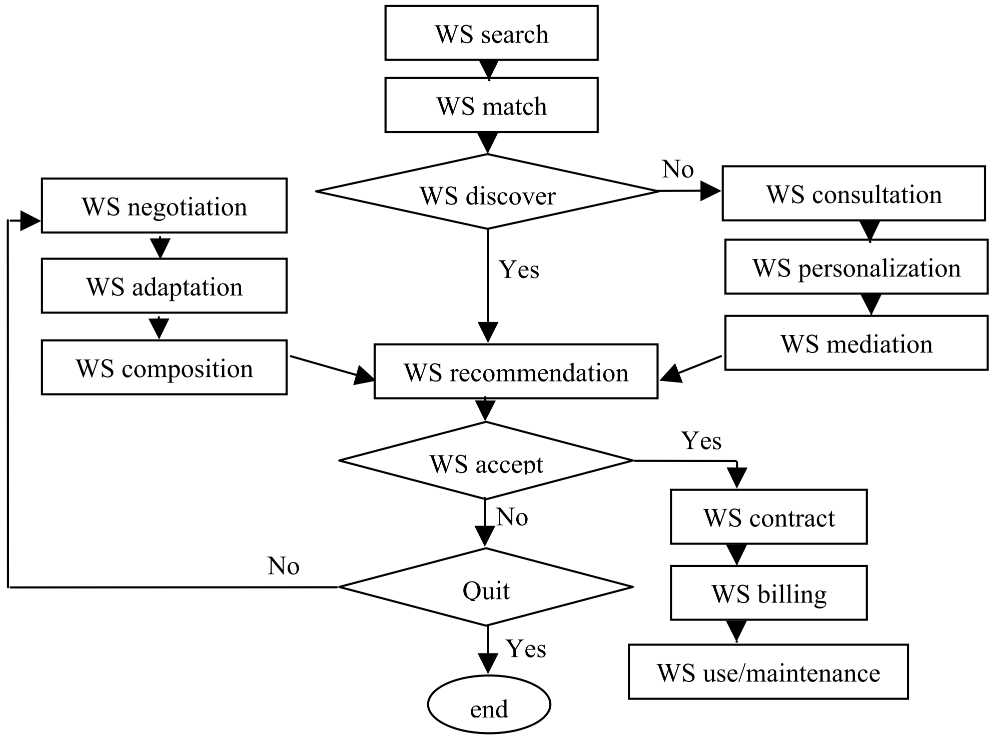

Figure 2: A requester's demand-driven web service lifecycle

C6: SIX DRIVING FACTORS FOR WEB SERVICES

So far throughout this article we have examined the main players involved in web services and a commonly understood demand-driven web service life cycle. Now we will outline some main driving factors for decision making in web services and argue that the proposed six driving factors (C6) are applicable to decision making in web services.

There has been extensive research on the different factors influencing web services. This is a common trend also occurring in the field of information systems (IS). For example, Chaffey (2007) lists the following common drivers applicable to e-Commerce: reduce costs/increase efficiency/profit, improve communication with customers/improve relationships, keep up with progress, improve communication with staff, keep up with competitors/competitive pressure, increase customer base/market share in existing markets, etc. Chen (2005), on the other hand, has analysed the driving forces concerning the adoption of Web service. In particular, many researchers have proposed models for e-commerce, web services and information systems. For instance, Paul Smith (1999) developed SOSTAC™, a generic framework for e-marketing planning. There are six stages in the SOSTAC™ framework: situation, objectives, strategy, tactics, actions and control (Chaffey 2007:340-345). In the following paragraphs, we will examine six commonly stated driving factors for web services and then propose a holistic model for decision making in web services taking into account WSLC. We call this model the

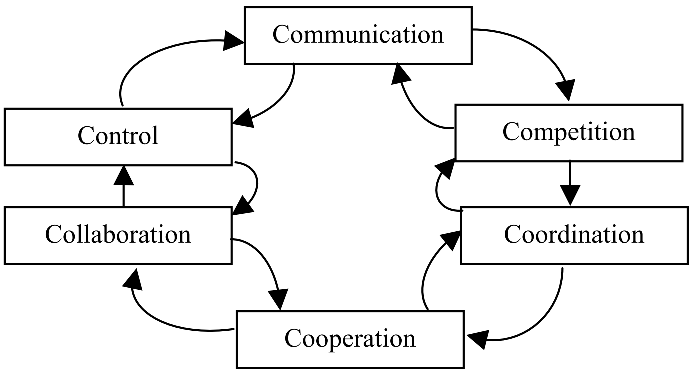

Figure 3: C^6: A strategic model for web services

C6, as shown in Figure 3, and it consists of communication, competition, coordination, cooperation, collaboration, and control. Communication, cooperation, coordination, collaboration have been studied in multi-agent systems (Sun and Finnie 2004) and social intelligence. In what follows, we will examine each of these six Cs and then look at their interrelationships and their influence on decision making in web services.

Communication

Communication can be considered as the basis for any interactions throughout the entire history of mankind through to the complex web service interactions of today. In the earlier study (Sun and Finnie 2004:83), discussions about communication in multiagent systems (MAS) were explored. In fact, communication serves as a basic means for physical agents (main payers mentioned early) and intelligent agents within multiagent web services to undertake any activities. Therefore, communication is usually considered as a key part of the infrastructure of web services (Chaffey 2007). In this technologically strong era, the main players, outlined earlier in this paper, concerned within web services can undertake their web service activities using modern Internet-based communication tools such as emails, blogs, voice over IP (Chaffey 2007:95-100). Therefore, any parties in web services have to consider which communication means are most effective for their own web service activities. Another main question for main players' decision making in web services is "how can I improve my communication with others in web services using IT techniques and tools?".

Competition

Competition is another important concept concerning web services. In fact, competition is a reality that all players in e-commerce, e-business and web services must face and address to be successful. In web services, we study the competition that web service providers, requesters and brokers face respectively in order to understand the whole market. Studying the competition acts as a basis for key decision making concerning the operation and success of web services. Competition analysis is usually represented by a "competitive threat analysis" in e-commerce, because it is a part of the well-established SWOT analysis. A SWOT analysis is a powerful tool that can help organisations analyse their resources in terms of Strengths and Weaknesses and match them against the external environment in terms of Opportunities and Threats in the context of e-business or e-commerce (Chaffey 2007:210). Any player in web services has to analyse the competition that he may be facing - who is the true competitive threat. For example, currently eBay (ebay.com) are facing tough competition in web services marketing in China from the TaoBao Company (taobao.com) (Ou and Davison 2009). It should be noted that competition is one of the important sources for both trust and deception in web services, the latter has drawn increasing attention from academics and industry (Ou and Sia 2009). One of the main questions for WS providers' decision making is "who are my competitors in terms of provision of related web services?".

Competition also has been focused on in terms of e-commerce and e-business (Chaffey 2007). For example, any e-business company always tries to resolve the competitive threats and get competitive advantage in the e-marketing.

Coordination

Coordination is related to a system of individual agents that all perform activities in a shared environment. It has been extensively studied in terms of multiagent systems (Sun and Finnie 2004). Coordination means the regulation of interactions between agents leading a system to successfully fulfil its key objectives (Denning and Yaholkovsky 2008). Coordination aims at managing the sometimes complex inter-dependencies between the activities of agents: Some coordination mechanism (such as mutual modelling, through planning or joint intentions) is essential if the activities that agents can engage in can interact in any way (Wooldridge 2002: 200-210). The main questions for main players' decision making in web services are "who can I coordinate with?" and "how can I coordinate with him?".

Cooperation

Cooperation is often proposed as one of the important concepts which differentiate MAS from other computing disciplines such as distributed computing. Generally speaking, to cooperate is to act with another or others towards a common purpose and for a common benefit (Sun and Finnie 2004:81). In other words, cooperation means playing in the same game with others according to a common set of behaviour rules (Denning and Yaholkovsky 2008). For web services, the motivation to cooperate is derived from one player's individual intention of maximising profit while minimising his cost. Therefore, cooperation in web services is beneficial to all parties involved. In web services, successful cooperation can be generated between agents that have not been previously cooperative through negotiating a mutually acceptable agreement to which they are both committed. The main questions for main players' decision making in web services are "who can I cooperate with?" and "how can I cooperate with him?".

It should be noted that coordination and cooperation are both weaker forms of working together than collaboration (Denning and Yaholkovsky 2008). Neither of these processes requires mutual support and agreement from all parties involved in web services.

Collaboration

Collaboration is essential for resolving large and complex problems that no one can find a way out of (Denning and Yaholkovsky 2008). Collaboration generally means working together synergistically. If one's work requires support and agreement of others before he can take action, he is collaboratively. Collaboration has drawn attention in web services. For example, Fox et al. (2002) develop a web services framework for collaboration taking into account collaboration protocols and systems. In web services, main players and also their corresponding intelligent agents undertake collaboration in order to be successful in activities in WSLC. For example, the WS providers collaborate with WS brokers to publish WS products more customer-friendly or make WS requestors more satisfactorily. The main questions for main players' decision making in web services are "who can I collaborate with?" and "how can I collaborate with him?".

Control

Control has been focused on in the fields of computer engineering and e-commerce. Control is also a stage in Smith's (1999) previously mentioned SOSTAC™ framework. It is important for many players in web services to control the activities in WSLC such as web service composition, discovery and recommendation (Nguyen and Kowalczyk 2007). Control in web services can be achieved by web services providers or brokers through a combination of traditional techniques such as marketing research to obtain the feedback of web service requesters' satisfaction and novel techniques such as analysis of web-server log files that use technology to monitor whether objectives are achieved (Chaffey 2007: 981). The web service requesters can achieve control based on the analysis of quality of web services available on the web, recommendation of web services by the providers or brokers. One of the main questions for WS providers' decision making is "how can I control the quality of the provided web services?".

From Figure 3 we can find that these Cs are interdependent in the context of web services. For instance, competition drives collaboration. Effective coordination facilitates cooperation and collaboration. Control also helps coordination, cooperation and collaboration. These Cs interact with each other in the context of main players in web services. For example, a web service provider communicates with a web service broker to analyse the competition situation that he is facing. He tries to coordinate with his peer providers, cooperate with the web service broker to present his web services. He tries to collaborate with his colleagues and control the quality of the provided web services, and so on.

In order to answer the above-mentioned questions, the corresponding analysis is required for each of Cs in order to make decisions in web services, that is, communication analysis, competition analysis, coordination analysis, collaboration analysis, cooperation analysis and control analysis. We will not go into each of them owing to the space limitation. In the rest of the section, we will examine the interrelationships between these six Cs in the context of decision making of main players in web services based on the strategic model, C^6, and the previously mentioned WSLC.

A HOLISTIC MODEL FOR DECISION MAKING IN WEB SERVICES

As discussed previously, web service providers, requesters and brokers can be considered as three main kinds of parties or players in web services. Each of these parties requires collaboration, coordination, and cooperation in order to work together to some extent. Each of them faces competition from its own parties; each must communicate with its members in the party and members in other parties in order to make decision in web services. Firstly, the above-mentioned six Cs are basic behaviours of the main players for decision making in any activity of web services taking into web service lifecycle (WSLC) (for example, from requester's demand perspective). Secondly, the above strategic model is human-centred model, whereas the demand-driven WSLC are web services transaction-centred one. People are decisive factors not only for traditional commerce and services, but also for e-commerce and web services. Further, the intelligent counterparts of human in traditional services are intelligent agents in web services (Sun and Finnie 2004). Therefore, there are communication, coordination, cooperation, collaboration, competition and control between main players, their corresponding intelligent agents to make decisions in web services, as shown in Figure 4. For example, cooperation, coordination, and collaboration among web services providers have drawn attention in web services. Cooperation, coordination, collaboration among web services provider agents are being researched in multagent web service systems. Web service requesters undertake cooperation, coordination, collaboration with web services provider agents in order to obtain web services. In particular, when one uses Google to search some information over the Internet means that he, as a web services requester, is cooperating with Google, as a web service provider agent, to obtain his services from web services. Taking this into account we can illustrate the interrelationships between main players and their corresponding intelligent agents in web services as a holistic model for decision making in web services, using Figure 4.

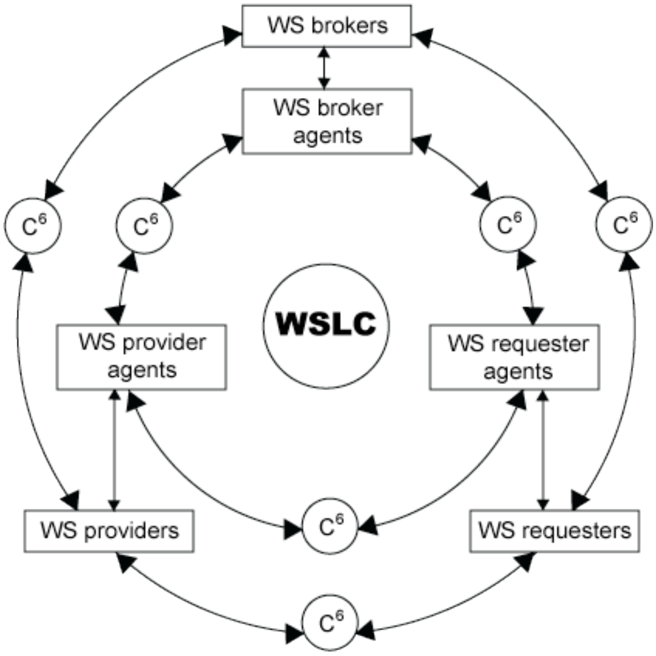

Figure 4: C^6: A holistic model for decision making in web services

We still represent this model as C^6 (for brevity). In this holistic model, from a service viewpoint, there are communication, competition, coordination, collaboration, cooperation and control between WS brokers and WS providers, between WS providers and WS requestors, between WS brokers and WS requestors to make decisions for undertaking the activities in the WSLC. From a perspective of multiagent systems, there are also communication, competition, coordination, collaboration, cooperation and control between WS broker agents and WS provider agents, between WS provider agents and WS requestor agents, between WS broker agents and WS requestor agents to make decisions for undertaking the activities in WSLC.

RELATED WORK

Web services have received an increasing attention from academia and industries. We have mentioned many researches related to our current research in this article. Further, there has been various researches focusing on the concerning elements of the proposed C6 models. Franklin (1996) explores a collection of examples of coordination without communication and argues that coordination with or without communication is a property of MASs. His work is related to the two Cs: communication and cooperation in MAS. Sun and Finnie (2004) examine three Cs in multiagent e-commerce: communication, cooperation and coordination and look at their interrelationships (Sun and Finnie 2004:81-84). Different from the three Cs focused on by Sun and Finnie (2004), Denning and Yaholkovsky (2008) examine a different grouping of three Cs for resolving large and complex problems: coordination, cooperation and collaboration. This leads to the proposition that at least four Cs should be examined in a unified way in web services: communication, coordination, cooperation and collaboration. The framework SOSTAC^{TM}, developed by Paul Smith (1999), used in e-business and e-commerce for management (Chaffey 2007) motivates us to consider the C^6 as a strong and solidly structured framework for decision making in web services. This motivation inspires us to look at web services, e-commerce and e-business, all of which have the six Cs playing critical role within them.

Integration of web services and multiagent systems has been extensively studied in the past years. For example, Nguyen and Kowalczyk (2007) propose an integration of web service with Jade agents, WS2Jade, which can deploy and control web services as agent services at run time for deployment flexibility and active service discovery. This work implies that the many players and/or their corresponding intelligent agents should control the activities in the WSDL efficiently.

CONCLUSIONS

This article looked at main players in web services and web service lifecycle and proposed a demand-driven web service lifecycle for web services requesters. It analysed six driving factors for web services and then proposed a holistic model for decision making in web services, C^6, which consists of six Cs: communication, competition, coordination, collaboration, cooperation and control. It also examined the interrelationships of these six Cs taking into account the main players' decision making in web services and web service lifecycle. The proposed approach will facilitate research and development of web services, e-services, service intelligence, service science and service computing. In future work, we will further develop the C^6 into a framework for decision making in web services based on more detailed literature review and practice in web services and providing detailed communication analysis, competition analysis, coordination analysis, collaboration analysis, cooperation analysis and control analysis based on a case study of applying C^6 in decision making in web services. We will also examine some concrete examples of web services in practices and how they map to the C^6 framework.

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